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NIOSH
Fire Fighter Fatality Investigation and Prevention Program

Death in the line of duty...

A Summary of a NIOSH fire fighter fatality investigation *August 19, 2002*

Fire Fighter Dies at Three-Alarm Structure Fire - New York

SUMMARY

On August 13, 2001, a 34-year-old male volunteer Fire Fighter responded on the first alarm to a working fire in a three-story, 60-unit senior citizens apartment complex. After fire extinguishment and rehabilitation (Rehab), the victim was performing a walk-through survey on the third floor during overhaul when he collapsed. Crew members carried him down the stairway and outside the apartment complex where paramedics assessed him and found him to be unresponsive, not breathing, and pulseless. Approximately 43 minutes later, despite cardiopulmonary resuscitation (CPR) and advanced life support (ALS) administered on the scene and at the hospital, the victim died. The death certificate and autopsy record, completed by the Associate Chief Medical Examiner, listed hypertrophic and arteriosclerotic cardiac disease as the immediate cause of death.

The following recommendations address some general health and safety issues. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These selected recommendations have not been evaluated by NIOSH, but they represent published research or consensus votes of technical committees of the National Fire Protection Association (NFPA) or fire service labor/management groups. While these recommendations could be used at this Fire Department, it is unlikely any of these measures could have prevented this victim's untimely death.

- ***Conduct mandatory preplacement medical evaluations consistent with NFPA 1582 to determine a candidate's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Provide mandatory annual medical evaluations consistent with NFPA 1582 to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.***
- ***Incorporate exercise stress tests into the Fire Department's medical evaluation program.***
- ***Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.***
- ***Carboxyhemoglobin levels should be tested on symptomatic or unresponsive fire fighters exposed to smoke.***

INTRODUCTION AND METHODS

On August 13, 2001, a 34-year-old male Fire Fighter lost consciousness during overhaul at a structure fire.

The **Fire Fighter Fatality Investigation and Prevention Program** is conducted by the National Institute for Occupational Safety and Health (NIOSH). The purpose of the program is to determine factors that cause or contribute to fire fighter deaths suffered in the line of duty. Identification of causal and contributing factors enable researchers and safety specialists to develop strategies for preventing future similar incidents. The program does not seek to determine fault or place blame on fire departments or individual fire fighters. To request additional copies of this report (specify the case number shown in the shield above), other fatality investigation reports, or further information, visit the Program Website at

www.cdc.gov/niosh/firehome.html

or call toll free **1-800-35-NIOSH**

Fire Fighter Dies at Three-Alarm Structure Fire - New York

Despite CPR and ALS administered by crew members, the ambulance crew, and in the emergency department, the victim died. NIOSH was notified of this fatality on August 14, 2001, by the United States Fire Administration. On September 17, 2001, NIOSH contacted the affected Fire Department to initiate the investigation. On October 3, 2001, a Safety and Occupational Health Specialist and a Visiting Scientist from the NIOSH Fire Fighter Fatality Investigation Team traveled to New York to conduct an on-site investigation of the incident.

During the investigation NIOSH personnel interviewed the following:

- Fire Chief
- Initial Incident Commander
- Crew members on duty with the victim
- Victim's personal physician
- Victim's wife

During the site visit NIOSH personnel reviewed the following:

- Fire Department policies and operating guidelines
- Fire Department training records
- Fire Department annual report for 2000
- Fire Department incident report
- Emergency medical service (ambulance) incident report
- Hospital emergency department report
- Fire Department physical examination protocols
- Death certificate
- Autopsy record
- Past medical records of the deceased

INVESTIGATIVE RESULTS

Incident. On August 13, 2001, at 1406 hours, the involved Fire Department (FD #2) was dispatched "second due" as part of an automatic mutual-aid alarm to a structure fire started by lightning. Responding were Engine 1 (Driver/Operator, Lieutenant, Advanced Fire Fighter/ Emergency Medical Technician [FF/EMT], and a Fire Fighter), previously dispatched to a motor-vehicle accident (MVA) and preparing to clear the scene, and Engine 4 (Driver/Operator and three Fire Fighters [including the victim]), at the Fire Department on standby for the MVA. Additional personnel (a Captain and two Fire Fighters) drove their privately owned vehicles (POV) to the scene.

The structure involved was a three-story, L-shaped, 60-unit senior citizens apartment complex of ordinary construction. (See photograph). The temperature was 77° Fahrenheit (F) and the relative humidity was 62%. During the incident, the temperature rose to 82° F and the relative humidity rose to 87%.

Engine 1 arrived on the scene at 1410 hours to find flames visible from the roof of the structure. The Engine 1 Lieutenant became the initial incident commander (IC). Engine 4 and an ambulance arrived on the scene at 1411 hours. Engine 4 connected to a nearby hydrant with a 5-inch supply hose and supplied Engine 1 with water. Both engines were positioned at the front of the structure. Crews pulled a 2½-inch hoseline and a 1¾-inch hoseline off Engine 1, and the deluge gun on Engine 4 was placed into service. The victim and the IC, both wearing full bunker gear and self-contained breathing apparatus (SCBA), on air, entered the structure and assisted the residents in walking to the exits. Another ambulance (Unit 2) and two additional mutual aid departments (FD #3: Ladder 1 and an ambulance, Rescue 9 and FD #4: Engine 1 and Engine 5) were dispatched.

The "first-due" fire department (FD #1: Engine 2 and Engine 5) responded at 1414 hours and arrived on the scene at 1417 hours. A second alarm was requested and a fourth mutual-aid department (FD #5/Ladder 8) was dispatched. A local sheriff, apartment complex staff, several bystanders, and fire fighters further assisted with the evacuation effort by

assisting the residents in walking from the exits to a safe area across the parking lot. After the residents were evacuated and accounted for, the victim walked to his Engine 1, removed his bunker coat, and sat down on the running board.

Ladder 1 arrived on the scene, was positioned behind the structure, and the master stream was directed onto the roof area of the right wing. Unit 4 from FD #1 (Captain and one Fire Fighter) and the ambulance from FD #2 responded. Rescue 9 from FD #3, Engine 1 from FD #4, and Unit 4 from FD #1 arrived on the scene, and the Unit 4 Captain assumed incident command (IC). Rescue 9 set up a Rehabilitation (Rehab) area. Ladder 8 arrived on the scene and was positioned in front of the structure to direct the master stream onto the center of the structure. The Assistant Chief (AC) from FD #4 was appointed Incident Safety Officer (ISO). The ISO responsibility was shortly transferred to a FF from FD #1. At 1435 hours, a cascade unit was requested (Unit 11) and a fifth mutual-aid department (FD #6) responded at 1442 hours, arriving on the scene at 1502 hours.

After spending approximately 1 hour at the scene, the victim and his crew members were soon directed to Rehab. In Rehab, the victim's vital signs were taken, and he received water and rested for 10 minutes. The Advanced FF/EMT from Engine 4 spoke with the victim, and he had no complaints or symptoms of chest pain or other medical condition.

As the fire was nearly extinguished, concern arose regarding personnel accountability. The IC ordered all crews to stop operations and report to the command post to assure accountability and to evaluate the operation. It was then reported that two fire fighters from FD #2 were missing. The emergency egress signal (air horns) was sounded, and all personnel evacuated the structure. The fire fighters were soon located outside the structure.

The east/west wing of the structure had 8 inches of water on the third floor, and the north/south wing had 3 to 4 inches of water on the third floor. Two submersible pumps were placed into service to remove the water. Three fire fighters, taking two 1½-inch hoselines and a thermal imaging camera (TIC), entered the north/south wing to check for fire extension and hot spots. In addition, three fire fighters (including the victim and the Engine 4 LT) took a 1¾-inch hoseline and a TIC and entered the east/west wing to check for fire extension and hot spots. The victim was wearing full bunker gear but no SCBA. A fire fighter advised the east/west group that there was nothing else to do, so they stood by. The victim began showing a probationary Fire Fighter where the fire started and what a fire wall actually looked like. As he was pointing to the fire wall, he collapsed (1600 hours).

The probationary Fire Fighter and another Fire Fighter assisted the victim to the floor and took his helmet off. The LT notified the IC that a man was down. The Rapid Intervention Team proceeded to the west wing, and Rescue 9 was alerted. Crew members carried the victim down the stairs and met incoming paramedics (carrying a Stokes basket) at the landing between the second and third floors. They took his bunker coat off, opened his airway, and placed the victim in the Stokes basket, then continued carrying him the remainder of the way down the stairs, out of the structure, and over to the Rehab area where paramedics began medical care at 1602 hours.

Assessment revealed the victim was unresponsive, with four breaths per minute and a pulse rate of 46. An oral airway was inserted, and a cardiac monitor was connected to the victim, revealing bradycardia (pulse rate of 46). Assisted ventilations via bag-valve-mask were begun. An IV line was inserted, and ALS medications were administered. At 1605 hours the cardiac monitor revealed bradycardia which progressed to ventricular fibrillation at 1606

hours. A cardiac shock was immediately administered. The victim was intubated, and two additional shocks were delivered with no change in patient status. CPR (chest compressions and assisted ventilations via bag-valve-mask) was begun. Three additional shocks were delivered and the heart rhythm reverted to asystole (no heartbeat). The victim was placed onto a backboard, loaded into Rescue 9, and transported to the hospital at 1618 hours. ALS measures and CPR were continued en route.

Rescue 9 arrived at the hospital emergency department (ED) at 1627 hours. Inside the ED, a cardiac monitor revealed asystole (no heartbeat). CPR and ALS measures continued until 1643 hours, when the victim was pronounced dead by the attending physician.

Medical Findings. The death certificate, completed by the Associate Chief Medical Examiner, listed "hypertrophic and arteriosclerotic cardiac disease" as the immediate cause of death and fatty liver as a contributing factor. A carboxyhemoglobin level (to assess the victim's carbon monoxide exposure) was not performed. Pertinent findings from the autopsy, also performed by the Associate Chief Medical Examiner, on August 14, 2001, included

Borderline cardiomegaly (an enlarged heart weighing 400 grams)
Dilated cardiac chambers
Moderate occlusive coronary artery disease (CAD)
- 70% narrowing of the left main coronary artery
- Some narrowing of the left anterior descending coronary artery
- Some narrowing of the right coronary arteries

Pulmonary congestion and edema
Fatty liver
Hepatosplenomegaly

According to the Associate Chief Medical Examiner, a microscopic examination of the heart was conducted; however, the autopsy report did not include any description of histologic findings of the heart muscle.

The Fire Fighter had the following risk factors for coronary artery disease (CAD): male gender, high blood pressure, high blood cholesterol, obesity, and physical inactivity. The victim was currently prescribed a medication to lower his blood pressure. In 2001 the victim had a routine physical examination given by his private physician. The exam revealed a height of 5' 9", a weight of 206 pounds, a blood pressure of 120/82, total cholesterol of 258 mg/dl, cholesterol/ HDL ratio of 6.14, LDL of 142 mg/dl, and triglycerides of 371 mg/dl. He was last cleared for fire fighting duties by a contract physician in 2000.

According to his wife and crew members, the victim had no complaints of chest pains or any other heart-related illness. He did not have a family history of heart disease. During the two weeks before and the day of the incident, the victim did not report any symptoms suggestive of angina or heart attack to anyone. The day of the incident, the victim worked around his house before responding to the call.

DESCRIPTION OF THE FIRE DEPARTMENT

At the time of the NIOSH investigation, the Fire Department consisted of 42 uniformed personnel and served a population of 27,000 residents in a geographic area of 52 square miles. There were two fire stations.

In 2000, the Fire Department responded to 176 calls: 108 EMS calls, 15 false calls, 13 service calls, 12 rescue calls, 8 hazardous-condition calls, 8 good-intent calls, 5 structure fires, 5 vehicle fires, 1 refuse fire, and 1 other fire call.

Training. The Fire Department requires all new fire fighter applicants to pass an interview by Department fire officers and the executive board, and they are voted on at a membership meeting before becoming a probationary fire fighter. Once accepted, the new probationary fire fighter must pass a physical examination performed by a physician contracted by the City. The fire fighter then receives the 42-hour Basic Fire Fighter course required by the State before becoming a certified Fire Fighter and performing interior structural fire-fighting duties.

Recurrent training occurs weekly. Fire fighters must attend 12 drills and pass the annual physical examination. There is no State minimum requirement for fire fighter recertification. The victim was a certified Fire Fighter, and he had 16 years of fire fighting experience.

Preemployment/Preplacement Evaluations. The Department requires a preemployment/preplacement medical evaluation for all new members, regardless of age. Components of this evaluation include the following:

A complete medical history
Vital signs
Physical examination
Pulmonary function test (PFT)
Gross hearing evaluation (either the Department Of Transportation (DOT) 5-foot whisper test or the 35-decibel tone bar test)
Vision screen

These evaluations are performed by a contract physician. Once this evaluation is complete, the contract physician makes a determination regarding medical clearance for fire-fighting duties and forwards this decision to the Fire Department.

Periodic Evaluations. Annual medical evaluations are required by this Department for all fire fighters. Components of the evaluation include the following:

A complete medical history
Vital signs
Physical examination
Pulmonary function test (for SCBA users)
Gross hearing evaluation (either the Department Of Transportation (DOT) 5-foot whisper test or the 35-decibel tone bar test)
Vision screen
Respirator fit testing

The contract physician performs the periodic medical evaluations. Medical clearance for self-contained breathing apparatus (SCBA) use and for fire suppression duties is required for all fire fighters. If an employee is injured or is ill and cannot participate in emergency responses or Department activities, the employee is evaluated by his or her personal physician, who forwards his or her recommendation regarding return to work to the Fire Department, which makes the final determination. No exercise (strength or aerobic) equipment is available for the fire fighters. No wellness/fitness or health maintenance programs are in place for the Department.

The victim was last cleared for duty by the contract physician in 2000. He did not exercise regularly.

DISCUSSION

In the United States, coronary artery disease (atherosclerosis) is the most common risk factor for cardiac arrest and sudden cardiac death.[1] Risk factors for its development include age over 45, male gender, family history of coronary artery disease, smoking, high blood pressure, high blood cholesterol, obesity, physical inactivity, and diabetes.[2,3] The victim had five of these risk factors (male gender, high blood pressure, high blood cholesterol, obesity, and physical inactivity).

The narrowing of the coronary arteries by atherosclerotic plaques occurs over many years, typically decades.[4] Heart attacks typically occur with the sudden development of complete blockage (occlusion) in one or more coronary arteries that have not developed a collateral blood supply.[5] This sudden blockage is primarily due to blood clots (thrombosis) forming on the top of atherosclerotic plaques.

Heart attacks are confirmed by any of the following: autopsy findings (thrombus formation), blood tests (cardiac isoenzymes), or ECG findings. The victim did not have a coronary artery thrombus on autopsy; he died before the cardiac isoenzymes became positive; and he had no heartbeat to show the characteristic findings of a heart attack on his ECG. Due to the victim's age and only moderate CAD, it is unlikely this victim had a heart attack. A more likely scenario is that his sudden death was due to some type of cardiac conduction abnormality. This could be due to a primary problem of the heart's conduction system or secondary to some type of cardiomyopathy.

Cardiomyopathy is a disease of the heart muscle not resulting from ischemia (reduced blood supply to the heart muscle), hypertension (high blood pressure), heart valve problems, or congenital abnormalities.[6] The victim's autopsy was significant for several reasons. First, on visual examination, the Associate Chief Medical Examiner noted dilated cardiac chambers. Dilated cardiomyopathy is a condition characterized by dilatation of the heart chambers and impaired ventricular contraction (pumping). Microscopic findings are nonspecific, typically being myocyte hypertrophy (best appreciated as nuclear hypertrophy [e.g., "box-car nuclei"]) with varying degrees of interstitial/perivascular fibrosis, or myofibrillar loss or myocyte atrophy.[7-8] Unfortunately the medical examiner did not include in the written report a description of the findings of the victim's heart muscle. Although most cases of dilated cardiomyopathy are of unknown etiology (idiopathic), a variety of acquired or hereditary disorders can cause the disorder. (Table 1) Although sudden death is rarely the initial presentation,[9-10] it is a common cause of death among idiopathic cardiomyopathy (IDC) patients, accounting for 28 percent of all IDC deaths.[8]

Although a variety of symptoms and medical tests can provide prognostic information, patients at greatest risk of sudden death or in need of anti-arrhythmic therapy cannot yet be prospectively identified.[8] Given the inability to identify patients at high risk for sudden death, the low degree of efficacy of anti-arrhythmic agents for IDC, the numerous side effects of these anti-arrhythmic agents, and the lack of symptoms in this Fire Fighter, it is unclear if an earlier diagnosis could have been made, let alone prevented his sudden death.

Investigations into the pathogenesis of IDC have focused on four basic mechanisms: (1) inherited factors, (2) viral myocarditis and other cytotoxic insults, (3) immune abnormalities, and (4) metabolic, energetic, and contractile abnormalities. These mechanisms are not mutually exclusive, and several may combine to produce clinical disease in susceptible patients. The inherited factors account for approximately one third of all IDC cases,[11-13] and 20 percent of patients with IDC have at least one first-degree relative (parent, sibling) with a decreased ejection fraction and cardiomegaly (enlarged heart).[11] Although IDC can be transmitted as a recessive or X-linked trait, autosomal dominant inheritance occurs most frequently and exhibits both clinical variability and genetic heterogeneity.[14]

Hypertrophic cardiomyopathy was listed on the death certificate as the cause of death. It is associated with sudden death in young men.[15-16] Autopsy findings are diagnostic: unexplained hypertrophy and microscopic findings of myocardial fiber disarray in

the hypertrophic area.[16] As mentioned before, the Associate Chief Medical Examiner's report did not include a written description of the heart muscle histology. It is important to determine if this condition was present because it is an inherited (autosomal dominant) disorder. First-degree relatives of this Fire Fighter may want to consult with their physicians regarding whether an echocardiogram is warranted to screen for IDC and/or hypertrophic cardiomyopathy since it is treatable.[15-17]

IDC and hypertrophic cardiomyopathy are not specifically addressed in the NFPA 1582 standard.[18] However, at a minimum they would be considered a Category B medical condition, defined as "a medical condition that, based on its severity or degree, **could** (our emphasis) preclude a person from performing as a fire fighter in a training or emergency operational environment by presenting a significant risk to the safety and health of the person or others." It is unclear whether the periodic medical evaluation recommended by NFPA 1582 would have detected these two conditions, let alone prevented, his tragic and untimely death.

RECOMMENDATIONS

The following recommendations address health and safety generally. It is unclear if any of these recommendations could have prevented the sudden cardiac arrest and subsequent death of this Fire Fighter. This list includes some preventive measures that have been recommended by other agencies to reduce the risk of on-the-job heart attacks and sudden cardiac arrest among fire fighters. These recommendations have not been evaluated by NIOSH, but they represent published research or consensus votes of technical committees of the NFPA or fire service labor/ management groups.

Recommendation #1: Conduct <u>mandatory</u> preplacement medical evaluations consistent with NFPA 1582 to determine a candidate's medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of preplacement medical evaluations and examinations for fire fighters can be found in *NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*,[18] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[19] The Department is not legally required to follow any of these standards. Nonetheless, we recommend the City and the Fire Department be consistent with the above guidelines.

In addition to providing guidance on the frequency and content of the medical evaluation, NFPA 1582 provides guidance on medical requirements for persons performing fire-fighting tasks. NFPA 1582 should be applied in a **confidential**, **nondiscriminatory** manner. Appendix D of NFPA 1582 provides guidance for fire department administrators regarding legal considerations in applying the standard.

Applying NFPA 1582 also involves economic issues. These economic concerns go beyond the costs of administering the medical program; they involve the personal and economic costs associated with the medical evaluation results. *NFPA 1500, Standard on Fire Department Occupational Safety and Health Program*, addresses these issues in Chapter 8-7.1 and 8-7.2.[20]

The success of medical programs hinges on protecting the affected fire fighter. The Department must (1) keep the medical records confidential, (2) provide alternate duty positions for fire fighters in rehabilitation programs, and (3) if the fire fighter is not medically

qualified to return to active fire-fighting duties, provide permanent alternate duty positions or other supportive and/or compensated alternatives.

Recommendation #2: Provide mandatory annual medical evaluations consistent with NFPA 1582 to determine fire fighters' medical ability to perform duties without presenting a significant risk to the safety and health of themselves or others.

Guidance regarding the content and frequency of periodic medical evaluations and examinations for fire fighters can be found in *NFPA 1582, Standard on Medical Requirements for Fire Fighters and Information for Fire Department Physicians*,[18] and in the report of the International Association of Fire Fighters/International Association of Fire Chiefs (IAFF/IAFC) wellness/fitness initiative.[19] The Department is not legally required to follow any of these standards. Nonetheless, we recommend the City and Fire Department **work together** to establish the content and frequency to be consistent with the above guidelines.

Recommendation #3: Incorporate exercise stress tests into the Fire Department's medical evaluation program.

NFPA 1582 and the IAFF/IAFC wellness/fitness initiative both recommend at least biannual EST for fire fighters.[18-19] They recommend that these tests begin at age 35 for those with CAD risk factors and at age 40 for those without CAD risk factors. The EST could be conducted by the fire fighter's personal physician or the City contract physician. If the fire fighter's personal physician conducts the test, the results must be communicated to the contracted physician, who should be responsible for decisions regarding medical clearance for fire-fighting duties.

Recommendation #4: Phase in a mandatory wellness/fitness program for fire fighters to reduce risk factors for cardiovascular disease and improve cardiovascular capacity.

Physical inactivity is the most prevalent modifiable risk factor for CAD in the United States. Additionally, physical inactivity, or lack of exercise, is associated with other risk factors, namely obesity and diabetes.[21] *NFPA 1500, Standard on Fire Department Occupational Safety and Health Program*, requires a wellness program that provides health promotion activities for preventing health problems and enhancing overall well-being.[20] In 1997, the International Association of Fire Fighters (IAFF) and the International Association of Fire Chiefs (IAFC) published a comprehensive Fire Service Joint Labor Management Wellness/Fitness Initiative to improve fire fighter quality of life and maintain physical and mental capabilities of fire fighters. Ten fire departments across the United States joined this effort to pool information about their physical fitness programs and to create a practical fire service program. They produced a manual and a video detailing elements of such a program.[19] The Fire Department should review these materials to identify applicable elements. Other large-city negotiated programs can also be reviewed as potential models.

Recommendation #5: Carboxyhemoglobin levels should be tested on symptomatic or unresponsive fire fighters exposed to smoke.

Unfortunately, a carboxyhemoglobin level was not done at the hospital; this would have provided a good assessment of the victim's exposure to carbon monoxide. It is unlikely, however, that his carboxyhemoglobin level would have been elevated given the victim's estimated time of smoke exposure and the fact that he wore an SCBA during initial fire-fighting operations. Furthermore, knowledge of his carboxyhemoglobin level would not have affected

his treatment or outcome since he was already receiving 100 percent oxygen by intubation and was pronounced dead shortly after arrival at the hospital. Nonetheless, to assist the investigation of fire-related deaths, we recommend performing carboxyhemoglobin levels to rule out carbon monoxide poisoning.

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INVESTIGATOR INFORMATION

This investigation was conducted by and the report written by Tommy N. Baldwin, MS, Safety and Occupational Health Specialist, and Richard Wittman, MD, Visiting Scientist. Mr. Baldwin is with the NIOSH Fire Fighter Fatality Investigation and Prevention Program, Cardiovascular Disease Component, located in Cincinnati, Ohio. Dr. Wittman is a visiting scientist from Harvard University, Boston, Massachusetts.

Table 1. Known Causes of Dilated Cardiomyopathy[8]

Toxins
- Ethanol
- Chemotherapeutic agents (doxorubicin, bleomycin)
- Cobalt
- Anti-retroviral agents (zidovudine, didanosine, zalcitabine)
- Phenothiazines
- Carbon monoxide
- Lead
- Cocaine
- Mercury

Metabolic Abnormalities
- Nutritional deficiencies (thiamine, selenium, carnitine)
- Endocrinologic disorders (hypothyroidism, acromegaly, thyrotoxicocis, Cushing's Disease, pheochromocytoma, diabetes mellitus)
- Electrolyte disturbances (hypocalcemia, hypophosphatemia)

Infectious
- Viral (coxsackie virus, cytomegalovirus, human immunodeficiency virus)
- Rickettsial
- Bacterial (diphtheria)
- Mycobacterial
- Fungal
- Parasitic (toxoplasmosis, trichinosis, Chagas' disease)

Noninfectious
- Collagen vascular disorders (scleroderma, lupus erythematosus , dermatomyositis)
- Hypersensitivity myocarditis
- Sarcoidosis
- Peripartum dysfuncion

Neuromuscular Causes
- Duchenne's muscular dystrophy
- Facioscapulohumeral muscular dystrophy
- Erb's limb-girdle dystrophy
- Myotonic dystrophy